Cukurova Medical Journal
ÇUKUROVA ÜNİVERSİTESİ TIP FAKÜLTESİ

Cukurova Med J 2020;45(3):1210-1216
DOI: 10.17826/cumj.780148

ARAŞTIRMA / RESEARCH

Contribution of preoperative magnetic resonance imaging in diagnosis and surgical treatment of anal fistula

Preoperatif manyetik rezonans görüntülemenin anal fistül tanı ve cerrahi tedavisine katkısı

Mehmet Bayrak[1], Yasemin Altıntaş[2], Ömer Alabaz[3], Medih Çeliktaş[2]

[1]Ortadogu Hospital, General Surgeon, [2]Radiologist, Adana, Turkey
[3]Cukurova University Faculty of Medicine, Department of General Surgeon, Adana, Turkey

Cukurova Medical Journal 2020;45 (3):1210-1216

Abstract

Purpose: This study aims to investigate the accuracy of MR imaging in patients with anal fistula and the information quantitatively added by MR imaging and to identify the group of patients where MR imaging is more likely to provide complementary information.

Materials and Methods: The present cohort was a retrospective work of consecutive patients diagnosed with primary anal fistula who underwent surgery and preoperative MR imaging between 15 January 2018 and 15 June 2020. Any complementary radiological information was derived from preoperative MR imaging reports. The inconsistencies were noted between surgical findings and MR imaging records.

Results: The study consisted of 160 patients with 179 tracts, 92 men and 68 women. The mean patient age was 44.6±10.1 (18-65) years. In total, 97 patients suffered from recurrent fistulas (60.6%). The specificity and sensitivity of MR imaging in detecting fistula tracts were 93.5 and 98.9 % %, respectively. The diagnostic accuracy of MR imaging in identifying the fistula tract and internal opening was 97.8 % and 97.5%, respectively. The contribution of preoperative MR imaging was statistically more significant if the external opening was over 3 cm from the anal canal (10.9% vs. 47.8%,) and when a horseshoe fistula was present (39.6% vs. 63.8%).

Conclusion: We found that MR imaging had high specificity, sensitivity, and diagnostic accuracy in discovering both fistula tracts and the internal opening, we consider that MR imaging should be used routinely in almost all simple and complex fistulas.

Keywords: Anal fistula, magnetic resonance imaging, surgical treatment

Öz

Amaç: Bu çalışma, anal fistülü olan hastalarda MR görüntülemenin doğruluğunu ve MR görüntülemeyle kantitatif olarak eklenen bilgileri araştırmayı ve MR görüntülemenin tamamlayıcı bilgi sağlama olasılığının daha yüksek olduğu hasta grubunu belirlemeyi amaçlamaktadır.

Gereç ve Yöntem: Bu çalışma 15 Ocak 2018-15 Haziran 2020 tarihleri arasında primer anal fistül tanısı alan, cerrahi ve preoperatif MR görüntüleme yapılan hastalar retrospektif olarak değerlendirildi. Preoperatif olarak çekilen manyetik resonance görüntüleri incelenerek tedavi ve teşhise katkı sağlayan ek bilgiler elde edildi. Cerrahi bulgular ile manyetik rezonans görüntüleme bulguları arasındaki tutarsızlıklar kaydedildi.

Bulgular: Çalışmamız 92 erkek ve 68 kadın olmak üzere 179 traktı olan 160 hastayı içermekte idi. Yaş ortalaması 44,6 ± 10,1 (18-65) yıl idi. Toplamda 97 (%60,6) hastada nüks fistül mevcuttu. MR görüntülemenin fistula traktlarının saptanmasında özgüllüğü ve duyarlılığı sırasıyla %93,5 ve %98,9 idi. MR görüntülemenin fistula traktını ve iç açıklığı saptamadaki tanısal doğruluğu sırasıyla %97,8 ve %97,5 idi. Ameliyat öncesi MR görüntülemenin katkısı, dış açıklık anal kanaldan 3 cm'in üzerinde ise ve at nalı fistülü bulunduğunda istatistiksel olarak daha anlamlıydı.

Sonuç: Manyetik rezonans görüntüleme hem fistula traktlarını hem de iç açıklığı tespit etmede yüksek özgüllüğe, duyarlılığa ve tanısal doğruluğa sahip olduğunu saptadık. Manyetik rezonans görüntülemenin tüm basit ve kompleks fistüllerde rutin olarak kullanılması gerektiğini öneriyoruz.

Anahtar kelimeler: Anal fistül, manyetik rezonans görüntüleme, cerrahi tedavi

Yazışma Adresi/Address for Correspondence: Dr. Mehmet Bayrak, Ortadogu Hospital, Adana, Turkey
Email: drmehmetbayrak@hotmail.com
Geliş tarihi/Received: 01.08.2020 Kabul tarihi/Accepted: 27.08.2020 Çevrimiçi yayın/Published online: 31.08.2020

INTRODUCTION

Perianal fistula is described as an abnormal communication between the anal canal and the perianal or perineal skin. It is a common lesion with high morbidity. Most common etiological factors include infection of criptoglandular tissue, crohn's disease, hematological malignancies that cause neutropenia, earlier surgical interventions for anal fissures or hemorrhoids, or trauma-related causes during labor [1,2].

The most commonly used method in the classification of perianal fistulas is the method used by Park et al, who classified the fistulas into 5 degrees according to perioperative physical examination. Based on this classification system fistula types include intersphincteric, transsphincteric, suprasphincteric, extrasphincteric and superficial grades [3]. Standard Practice Task Force (SPTF), developed by the American Society of Colorectal Surgeons, classifies anal fistulas as simple or complex [4,5].

While examining the features of anal fistulas in history and physical examination, the presence of external openings, internal openings, main tract, lateral extensions originating from the main tract, and other fistula related complications should be reviewed[6]. There are various diagnostic methods for the evaluation of anal fistulas. Fistulography, computed tomography (CT), endoanal ultrasonography (EUS), and MR imaging can be used to describe anal fistulas. Fistulography is not preferred due to low diagnostic accuracy[6]. The use of CT in the evaluation of anal fistula is limited due to low soft-tissue contrast and need to increase the contrast by cannulating a fistula tract[8]. Although studies are showing that EUS provided similar results as MR imaging, it has been reported in the literature that it has poorer results than MR imaging because it is operator dependent and cannot evaluate tissues far away from the ultrasound probe[2,9]. MR imaging is the diagnostic method of choice and the gold standard to evaluate and analyze anal fistulas[7]. It is recommended to perform in all recurrent and complex anal fistulas[10]. The MR imaging determines the clockwise of the internal opening of the fistula tract, the distance of the internal opening from the anal verge, the fistula type, secondary tract, extension, exit side, tract diameter, presence of horseshoe fistulas, associated abscess and presence of anovaginal fistula[11].

There are very few studies involving in which patients should experience MR imaging and limited cohorts involving a large number of patients[12]. It remains unclear whether a surgical management plan drawn after a physical examination and history analysis for anal fistulas will benefit from preoperative MR imaging by providing additional information that cannot be detected even during surgery. Therefore, this study aims to investigate the accuracy of MR imaging in patients with anal fistula and the information quantitatively added by MR imaging and to identify the group of patients where MR imaging is more likely to provide complementary information.

MATERIALS AND METHODS

The present cohort was a retrospective work of consecutive patients diagnosed with primary anal fistula who underwent surgery and preoperative MR imaging between 15 January 2018 and 15 June 2020. Patients who developed a fistula due to Crohn's disease, who had preoperative MR imaging at another center, preexisting incontinence, or local irradiation were excluded. Recurrent fistulas were diagnosed from the patient's history and anterior fistula in women with a physical examination. The Cukurova University Clinical Ethical Board approved the study which is a reference number of 101, 3 July 2020. All aspects of the study were performed according to the principles of the declaration of Helsinki (64th, 2013).

All surgeries were performed by two surgeons with more than 20 years of experience. Age, gender, body mass index (BMI), examination findings under anesthesia, Park's, and SPTF classification were obtained from surgical findings. A comprehensive history was obtained and then detailed physical examination involving rectal and anal examination, and examination and rectoscope were performed in the outpatient clinic. The features of the exams were recorded in proforma. Then MR imaging of the perianal area was performed. Patients with a high risk of incontinence (high- transsphincteric, suprasphincteric, extrasphincteric, multiple tracts, recurrent fistulas, anterior transsphincteric fistulas in woman) after treatment were defined as complex fistula. Any complementary radiological information, such as associated abscess, additional tract, horseshoe tract, any extensions, presence of additional internal and external opening, complex fistula were derived from MR imaging reports assess by radiologists. Findings missed by MR imaging or over-diagnosed with MR imaging were then cautiously reported.

These inaccuracies of MR imaging were employed to compute the sensitivity, specificity, and accuracy of the MR imaging scan.

Any inconsistency was noted between surgical findings and MR imaging records. According to the contribution of preoperative MR imaging, two workgroups were created: significant and insignificant contribution groups. The significant group identified participants with blind pathways, undiagnosed abscess, or horseshoe fistulas under physical investigation; those with a fistula degree were evaluated further after preoperative MR imaging; the localization of the internal opening is different from that defined with the physical investigation.

Magnetic resonance imaging

MR images were evaluated by a radiologist with 15 years of experience. All MR images 1.5 Tesla device (Philips Symphony 1.5T). employing a 4-channels phased-array sense body coil. The long axis of the anal canal was defined by applying the midline sagittal localization scans. Following coronal and transfers short inversion recovery sequences were arranged in accordance with the anal canal axis. Further axial T1-weighted *a*nd coronal T2-weighted sequences were carried out in all cases in accordance with the anal canal axis. Intravenous contrast agent was used in all patients, except for contraindications to the contrast agent.

The radiologists recorded their information considering fistula type, external and internal opening, horseshoe tract, and if present secondary pathways. The radial site of the internal opening was defined according to the clock position (6 o'clock posterior). Secondary extensions and accompanying abscesses were defined by their anatomical location such as intersphincteric, extrasphincteric, ischioanal, or ischiorectal. Fluid collections with peripheral contrast enhancement and visualized as the extension of fistula were defined as an abscess. The abscesses extend ing to either side of the anal canal were defined as horseshoe abscesses. The median time between MR imaging scan and surgery was 3 days.

Statistical analysis

For the primary endpoint, the study aims to determine the clinical characteristics (history and physical examination) that are likely to benefit from preoperative MR imaging. The study cohort of 160 patients (categorized into significant vs. nonsignificant MRI contribution groups) provides 80% power with a 5% type-I error level to statistically identify significant differences ranging between 15% and 25% for the clinical findings observed in these two groups.

As a secondary endpoint, the concordance between the classification schemes with and without the use of information from MR imaging (Parks and St. James classifications, respectively) was analyzed. Descriptive statistics were provided as mean and standard deviation for age and as percentages for the categorical variables. The difference between groups was analyzed using chi-square or Fisher's test. In this study, sensitivity, specificity, positive predictive values, and negative predictive values between pet and pathologic outcomes were evaluated and differences between methods were evaluated 2019 MedCalc Software Ltd. A p-value of <0.05 was used as the cutoff to infer statistical significance.

RESULTS

The study consisted of 160 patients with 179 tracts, 92 men and 68 women. The mean patient age was 44.6±10.1 (18-65) years. In total, 97 patients suffered from recurrent fistulas (60.6%). As per Park's classification, the fistula were grade 1 in 40, grade 2 in 14, grade 3 in 36, grade 4 in 59, and grade 5 in 11 (Table 1).

The tract was missed by an MR imaging scan in two patients and wrongly reported in two patients. The internal opening was missed in two and wrongly reported in two cases. The specificity and sensitivity of MR imaging in detecting fistula tracts were 93.5 and 98.9 % %, respectively. The specificity and sensitivity diagnosing the internal opening of the tracts were 93.5 % and 98.7 respectively. The diagnostic accuracy of MR imaging in identifying the fistula tract and internal opening was 97.8 % and 97.5%, respectively (Table 2).

MR imaging contributed important information about fistula features in 101 patients (56.4%). The added contributions were the existence of additional tracts in 25 (15.6%), horseshoe tract in 19 (11.9%), supra levator in 7 (4.4 %) (figure 1), associated abscess in 4 (2.5%) (figure 2) and an additional existence of internal opening in one patient (0.6%). Prior to MR imaging, on clinical examination, 100 (62.5%) fistula appeared simple and 60 (37.5%) fistula were complex. But, MR imaging scan revealed that

31/100 (31.0%) simple fistula were in fact complex fistulaIn these 31 patients, 50 complex parameters (4 abscesses,19 multiple tracts, 7 supra levator extensions,19 horseshoe tracts, and 1 multiple internal opening) were discovered with MR imaging scan, unknown to the surgeon.MR imaging also added further significant information (additional tract, internal opening or abscess, supra levator extension, or horseshoe tract) in 91/160 (56.8%) complex fistulae.

Table 1.Patient's characteristics

Variable	**n**	**%**
Age years(mean ±SD*)		44.6±10.1
Gender		
Female	68	42.5
Male	92	57.5
BMI * * (mean ±SD*, kg/m^2)		30.5±3.4
Parks classification		
Grade 1	40	25
Grade 2	14	8.7
Grade 3	36	22.5
Grade 4	59	36.9
Grade 5	11	6.9
SPTF †		
Simple	100	62.5
Complex	60	37.5
External opening >3 cm	69	43.2
Internal opening distance from anal verge>2 cm	119	74.4
Horseshoe	17	10.7
Associated abscess	9	5.7
Recurrent	97	60.6
Multiple tract	46	28.7
Anterior in female	2	1.3
Supralevator extension	5	3.2

* **SD:** standard deviation **;** ****BMI:** body mass index**;** † **SPTF**: standard practice task force

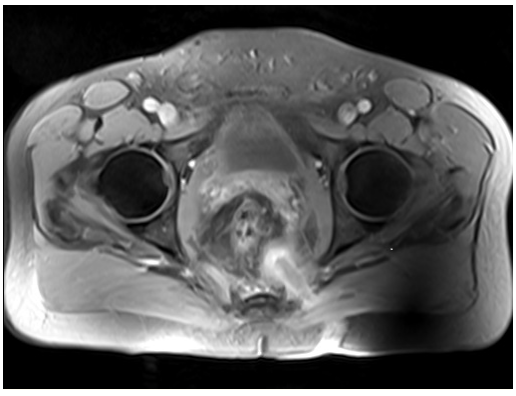

Figure 1. Axial contrast-enhanced T1-weighted image reveals fistula tract; external opening arising from the lateral gluteal region with supralevator extension, and peripheral contrast enhancement.

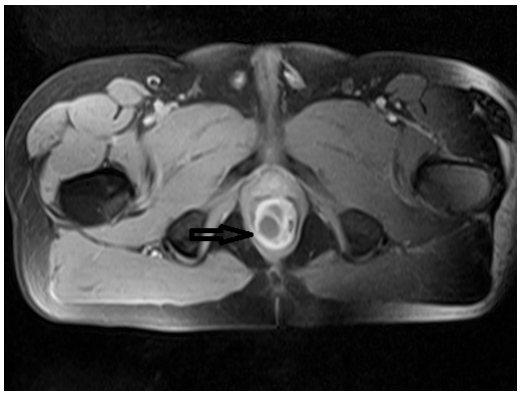

Figure 2. Axial contrast-enhanced T1-weighted image reveals an abscess (arrow) in intersphincteric space resulting from interhemispheric fistula.

Table 2. Accuracy of MR imaging in anal fistula patients

	Number of tract =179	Number of internal opening=157
Accurately diagnosed	177	155
Missed	2	2
Misdiagnosed	2	2
Sensitivity	98.9 % (95% CI 95.9-99.8)	98.7 %(95% CI 94.4-99.8)
Specificity	93.5 % (95% CI 78.6-99.2)	93.5 %(95% CI 78.6-99.2)
Accuracy	97.8 % (95% CI 94.4-99.4)	97.5 %(95% CI 93.7-99.3)

Table 3. Association of clinical findings with significant contribution of MR imaging on surgical management

		Impact of MR imaging on operation			
		No effect n(%)	**Significant n(%)**	**Total n(%)**	***P***
SPTF* classifiction	Simple	65(65%)	35(35%)	100(62.5%)	0,133
	Complex	31(51.6%)	29(48.3%)	60(37.5%)	
Park's classisfication	Grade 1	36 (90.0%)	4(10.0%)	40(25.0%)	
	Grade 2	8(57.1%)	6 (43.9%)	14(8.7%)	
	Grade 3	7 19.4%)	29 (80.6%)	36(22.5%)	0,001
	Grade 4	8 (13.5%)	51(86.5%)	59(36.9%)	
	Grade 5	2 (18.1%)	9(81.9%)	11(6.9%)	
External openning >3cm	Present	36(52.1%)	3 (47.9%)	69(43.2%)	0,0001
Recurrent case	Presenet	56 (57.7%)	41(42.3%)	97(60.6%)	0,028
Horseshoe fistula	Present	12 (34.2%)	23(65.8%)	35(21.9%)	0,0001
Number of external openings	1	85 (70.2%)	36 (29.8%)	121(75.6%)	0,210
	2	15(48.3%)	16(51.7%)	31(19.4%)	
	3	4(66.6%)	2 (33.4%)	6(3.8%)	
	4	1(50.0%)	1(50.0%)	2(1.2%)	
Internal opening distance from the anal verge >2cm	Present	63(52.9%)	56(47.1%)	119(74.4%)	0,0001

***SPTF**: standard practice task force

DISCUSSION

There have been very few studies examining the assessment of MR imaging in anal fistulas and comparing them with operation findings [13-19]. The use of MR imaging in the evaluation of anal fistulas has been increasingly becoming the gold standard. Many studies have demonstrated the superiority of MR imaging over endoanal ultrasonography [13,20,21]. and fistulography [18]. When MR imaging findings are supported by intraoperative findings, they can be more confirmed [13-19]. Surgical treatment of anal fistulas needs the recognition of the course of primary and secondary pathways and their relationship with the sphincteric muscles to properly treat the fistula and empty if any existing abscesses. Physical investigation alone may not be enough to delineate these features [13] and recurrence is usually due to missed infective foci at the first surgery [2, 22]. This study confirmed that MR imaging has a very high sensitivity, specificity, and diagnostic accuracy to estimate the number, location, and site of the internal opening of the fistula tracts. With 160 patients, our study presents one of the largest series in the literature and identifies the group of patients for which the radiologic evaluation of the fistula using MR imaging significantly contributes to the surgical management of the disease. MR imaging also provided significant knowledge considering complex variables of anal fistula in half of the patients. Detection of higher Parks grades, a distance of external opening of the fistula from the anal canal, internal opening distance from the anal verge, horseshoe fistulas, and complex fistulas are indicative of significant MR imaging contribution following clinical evaluation.

Garg et al. [12] in a study evaluating MR imaging contribution to surgical management in 229 patients have reported that MR imaging added significant information in patients with additional tracts, horseshoe tracts, supra levator extension, unsuspected abscess, and multiple internal openings. Using these parameters, they concluded that MR

imaging added significant information to 46.7% of the surgeries. In our study, using these parameters, MR imaging added significant fistula characterization changed by 56.4%.

In an article by Beets-Tan et al. [23], when the researchers delivered MR imaging results to the surgeon just before he decided to conclude the surgery, the surgeon decided to continue the surgery in 21% (12/56) of the patients based on information obtained from the MRI. A relatively smaller study of 40 patients by Mullen et al. [17] has shown that in cases where it was able to correctly identify the anatomical detail of the fistula, establish the need of extended surgery, correlate with EUS, or rule out a suspected fistula, MR imaging positively contributed to the surgical management of the patient. They concluded that such a positive contribution of MR imaging could be as high as 85% if used in selected cases. The positive contribution of MR imaging to clinical assessment has also been shown in studies by Chapple et al. [24] and Spencer et al. [25], which demonstrated that compared with initial surgical exploration, MR imaging findings were a better predictor of both satisfactory surgery and need for re-operation.

In a study by Konan A. et al.[26], MR imaging proved to change the operation when it delineated fistula characteristics, which could not be identified by physical examination or when the fistula grade was assessed to be higher than that of Parks classification after MR imaging assessment. With these criteria, MR imaging changed the operation in 33% of the cases. This ratio was 85% and 87% for Parks grade 3 and 4, respectively. They have also shown a significant contribution of MR imaging in detecting complex fistulas. In their research, the benefit of MRI was significantly more for fistulas in which external opening was over 2 cm from the anal canal. Similarly, in our study, the external opening being 3 cm above from the anal canal showed that MRI was significantly more beneficial. Also, in our study for the first time in the literature, it has been shown that MR imaging is significantly beneficial if the internal opening from the anal verge is over 2 cm.

Few studies have pointed out the false-negative results of the MR imaging [24, 27,28]. MR imaging failed to identify two fistulae tracts and two internal openings in our study. MR imaging may misdiagnose thin fistulas as fibrous tracts in the absence of inflammatory findings, yielding false-negative results.

The limitation of this study is that the information is evaluated retrospectively, representing our experience with preoperative MR imaging for primary fistulas. Secondly it was not double-blinded study.

We found that MR imaging had high specificity, sensitivity, and diagnostic accuracy in discovering both fistula tracts and the internal opening. Our study revealed that MR imaging added important information about complex parameters such as additional tract or internal opening, associated abscess, horseshoe path, and supra levator extension in nearly half of patients who had a simple and complex fistula. We assessed and demonstrated for the first time in the literature the added value of MR imaging for anal fistulas with an external opening over 3 cm from the anal canal and internal opening distance from anal verge more than 2 cm. Moreover, we identified other useful indications for MR imaging, such as the complex and higher grade fistulas. In patients with anal fistulas, significant information on the routine history and clinical examination is overlooked. Therefore, we consider that MR imaging should be used in all high-risk and complex fistulas in order to preserve continence, which is a restrictive effect in fistula surgery.

Yazar Katkıları: Çalışma konsepti/Tasarımı: YA, MB; Veri toplama: YA, MB, MA; Veri analizi ve yorumlama: YA, MB, ÖA; Yazı taslağı: YA, MB, ÖA; İçeriğin eleştirel incelenmesi: YA, MB, MÇ; Son onay ve sorumluluk: MB, YA, ÖA, MÇ; Teknik ve malzeme desteği: YA; Süpervizyon: ÖA, MÇ; Fon sağlama (mevcut ise): yok.
Etik Onay: Bu çalışma için Çukurova Üniversitesi Tıp Fakültesi Girişimsel Olmayan Klinik Araştırmalar Etik Kurulundan 03.07.2020 tarih ve 101/44 sayılı kararı ile etik onay alınmıştır
Hakem Değerlendirmesi: Dış bağımsız.
Çıkar Çatışması: Yazarlar çıkar çatışması beyan etmemişlerdir.
Finansal Destek: Yazarlar finansal destek beyan etmemişlerdir.

Author Contributions: Concept/Design : YA, MB; Data acquisition: YA, MB, MA; Data analysis and interpretation: YA, MB, ÖA; Drafting manuscript: YA, MB, ÖA; Critical revision of manuscript: YA, MB, MÇ; Final approval and accountability: MB, YA, ÖA, MÇ; Technical or material support: YA; Supervision: ÖA, MÇ; Securing funding (if available): n/a.
Ethical Approval: For this study, ethics approval was obtained from the Ethics Committee of non-interventional clinical research of the Faculty of Medicine of the University of Chukurov with the decision dated 03.07.2020 and numbered 101/44
Peer-review: Externally peer-reviewed.
Conflict of Interest: Authors declared no conflict of interest.
Financial Disclosure: Authors declared no financial support

REFERENCES

1. Krieglstein CF. Surgical procedures for perianal sepsis: ıschiorectal abscesses, fistulas, and pilonidal sinus. In: Thomas WEG, Senninger N (eds). Short Stay Surgery. Springer, Berlin, 2008;15:295–308.
2. Halligan S, Stoker J. Imaging of fistula in ano. Radiology. 2006;239:18–33.
3. Parks AG, Gordon PH, Hardcastle JD. A classification of fistula-in-ano. Br J Surg. 1976;63:1–12.
4. Whiteford MH, Kilkenny J 3rd, Hyman N, Buie WD, Cohen J, Orsay C et al. Standards Practice Task Force; American Society of Colon and Rectal Surgeons. Practice parameters for the treatment of perianal abscess and fistula-in-ano (revised). Dis Colon Rectum. 2005;48:1337-42.

5. Morris J, Spencer JA, Ambrose NS. MR imaging classification of perianal fistulas and its implications for patient management. Radiographics. 2000;20:623–35.
6. Goodsall DH, Miles WE. Diseases of the Anus and Rectum. London: Longmans, Green; 1900.
7. Kuijpers HC, Schulpen T. Fistulography for fistula-in-ano. Is it useful? Dis Colon Rectum. 1985;28:103–4.
8. Liang C, Lu Y, Zhao B, Du Y, Wang C, Jiang W. Imaging of anal fistulas: comparison of computed tomographic fistulography and magnetic resonance imaging. Korean J Radiol. 2014;15:712-23.
9. Siddiqui MR, Ashrafian H, Tozer P, Daulatzai N, Burling D, Hart A et al. A diagnostic accuracy meta-analysis of endoanal ultrasound and MRI for perianal fistula assessment. Dis Colon Rectum. 2012;55:576-85.
10. Williams JG, Farrands PA, Williams AB, Taylor BA, Lunniss PJ, Sagar PM, Varma JS et al. The treatment of anal fistula: ACPGBI position statement. Colorectal Dis. 2007;94:18-50.
11. Thipphavong S, Costa AF, Ali HA, Wang DC, Brar MS, Jhaveri KS. Structured reporting of MRI for perianal fistula. Abdom Radiol (NY). 2019;44:1295-305.
12. Garg P, Singh P, Kaur B. Magnetic Resonance Imaging (MRI): Operative Findings Correlation in 229 Fistula-in-Ano Patients. World J Surg. 2017;41:1618-24.
13. Buchanan GN, Halligan S, Bartram CI, Williams AB, Tarroni D, Cohen CR. Clinical examination, endosonography, and MR imaging in preoperative assessment of fistula in ano: comparison with outcome-based reference standard. Radiology. 2004;233:674-81.
14. Buchanan GN, Halligan S, Williams AB, Cohen CR, Tarroni D, Phillips RK, et al. Magnetic resonance imaging for primary fistula in ano. Br J Surg. 2003;90:877-81.
15. Buchanan G, Halligan S, Williams A, Cohen CR, Tarroni D, Phillips RK, et al. Effect of MRI on clinical outcome of recurrent fistula-in-ano. Lancet. 2002;360:1661-2.
16. Beckingham IJ, Spencer JA, Ward J, Dyke GW, Adams C, Ambrose NS. Prospective evaluation of dynamic contrast enhanced magnetic resonance imaging in the evaluation of fistula in ano. Br J Surg. 1996;83:1396-8.
17. Mullen R, Deveraj S, Suttie SA, Matthews AG, Yalamarthi S. MR imaging of fistula in ano: indications and contribution to surgical assessment. Acta Chir Belg. 2011;111:393-7.
18. Schwartz DA, Wiersema MJ, Dudiak KM, Fletcher JG, Clain JE, Tremaine WJ et al. A comparison of endoscopic ultrasound, magnetic resonance imaging, and exam under anesthesia for evaluation of Crohn's perianal fistulas. Gastroenterology. 2001;121:1064-72.
19. Orsoni P, Barthet M, Portier F, Panuel M, Desjeux A, Grimaud JC. Prospective comparison of endosonography, magnetic resonance imaging and surgical findings in anorectal fistula and abscess complicating Crohn's disease. Br J Surg. 1999;86:360-4.
20. Hussain SM, Stoker J, Schouten WR, Hop WC, Laméris JS. Fistula in ano: endoanal sonography versus endoanal MR imaging in classification. Radiology. 1996;200:475-81.
21. Maier AG, Funovics MA, Kreuzer SH, Herbst F, Wunderlich M, Teleky BK et al. Evaluation of perianal sepsis: comparison of anal endosonography and magnetic resonance imaging. J Magn Reson Imaging. 2001;14:254-60.
22. Practice parameters for treatment of fistula-in-ano. The Standards Practice Task Force. The American Society of Colon and Rectal Surgeons. Dis Colon Rectum. 1996;39:1361-2.
23. Beets-Tan RG, Beets GL, van der Hoop AG et al. Preoperative MR imaging of anal fistulas: Does it really help the surgeon? Radiology 2001; 218:75-84.
24. Chapple KS, Spencer JA, Windsor AC, Wilson D, Ward J, Ambrose NS. Prognostic value of magnetic resonance imaging in the management of fistula-in-ano. Dis Colon Rectum. 2000;43:511-6.
25. Spencer JA, Chapple K, Wilson D, Ward J, Windsor AC, Ambrose NS. Outcome after surgery for perianal fistula: predictive value of MR imaging. AJR Am J Roentgenol. 1998;171:403–6.
26. Konan A, Onur MR, Özmen MN. The contribution of preoperative MRI to the surgical management of anal fistulas. Diagn Interv Radiol. 2018 ;24:321-7.
27. Myhr GE, Myrvold HE, Nilsen G, Thoresen JE, Rinck PA. Perianal fistulas: use of MR imaging for diagnosis. Radiology. 1994;191:545–9.
28. Chauhan NS, Sood D, Shukla A. Magnetic resonance imaging (MRI) characterization of perianal fistulous disease in a rural based tertiary hospital of North India. Pol J Radiol. 2016;81:611–7.